



## SCHOOL OF BUSINESS AND ECONOMICS

### KING INSTITUTE FOR REGIONAL ECONOMIC STUDIES (KIRES)

#### KIRES Report No. 23, June 2022

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### **A Statistical Model to Predict U.S. Monthly Average Gasoline Prices**

#### Introduction and Background

Gasoline is unique among the products produced and consumed in the United States. No other commodity has its price so publicly displayed along streets and highways stretching across the country, and no other commodity catches the attention of so many individuals, including elected officials and media, when it suddenly becomes more expensive. And, more expensive it has become; from January 2020 through May 2022, the U.S. monthly average pump price for regular gasoline rose from \$2.20 per gallon to \$4.44 per gallon, including a 33 cents per gallon increase from April to May 2022.

In this paper, we examine relationships among prices for crude oil, the wholesale price of gasoline, and the retail or pump price for regular gasoline. Our primary objective is to develop a statistical model to predict U.S. monthly average prices of regular gasoline based on changes in crude oil costs and wholesale gasoline prices. We also analyze changes in the retail margin – the difference between the wholesale price of gasoline and the retail price. A unique feature of our study is that we include changes in the retail margin as an explanatory variable in the statistical model.

Our statistical model is based on national average monthly prices covering January 2020 through May 2022. This was a period of extremes in oil and gas markets brought about by the global Covid-19 pandemic and, more recently, Russia’s invasion of Ukraine.

#### Recent Trends in Oil and Gas Markets

Figure 1 shows recent trends in oil and gas markets, based on monthly price and cost data (presented in Table 1), as reported by the U.S. Energy Information Administration (EIA). Throughout the 29 months covered in this study, the three series shown in Figure 1 – wholesale and retail gasoline prices and the refiner average acquisition cost of crude oil (a composite of domestic and imported crude oil prices) – pretty much moved “hand-in-glove”.

As economies were locked down to combat COVID-19, crude oil prices plunged in the early months of 2020 with the refiner acquisition cost falling from an average of \$57.92 per barrel in January to a low of \$19.32 in April. Similar declines from January to April occurred in wholesale and retail gasoline prices; the monthly average wholesale price fell from \$1.74 to 65 cents per gallon while the average retail price dropped from \$2.55 to \$1.84 per gallon.

As the U.S. economy rebounded and demand for fuel strengthened, fuel prices trended upward from the lows of April 2020. However, it wasn't until February 2021 (March 2021 for the retail gasoline price) that average monthly prices exceeded their January 2020 values. Fuel prices rose throughout 2021 and early 2022, hitting a peak in May with the average pump price for gasoline reaching \$4.44 per gallon.

### The Statistical Model

Development of the statistical model is a two-step process described below:

Step 1: Develop a linear regression equation to quantify the relationship between the U.S. monthly average wholesale price of gasoline (W) and the monthly average refiner acquisition cost of crude oil (C). The wholesale price includes the crude oil cost, distribution costs and refinery costs and profits. On average, the refiner acquisition cost of crude oil accounted for 73 percent of the wholesale gasoline price during the 29-month period of our study.

The estimated equation is:

(1)  $W = 8.17 + 3.11 * C$ . The equation explained 97 percent of month-to-month changes in average wholesale gasoline prices over the 29-month time period. The equation indicates that for each \$1 per barrel change in crude oil cost, the wholesale price changes by 3.1 cents per gallon (Table 1 and Figure 2).

Step 2: Develop a procedure to quantify the relationship between the U.S. monthly average retail price of gasoline (R) and the wholesale price (W). The wholesale price is what retail station owners pay for gasoline. The retail price of gasoline consists of the wholesale price, State, Federal and local taxes, operating costs, and the retailer's markup. On average, the wholesale price accounted for 70 percent of the retail price during the study period.

By definition, the retail price is the wholesale price plus the retail margin (M). That is,  $R = W + M$ . If month-to-month margins were relatively stable, R could be quite simply expressed as a function of W. Unfortunately, this is not the case. The average margin for the 29 months was 84 cents per gallon. However, margins ranged from a low of 59 cents in May 2022 to a high of 119 cents per gallon in April 2020. Inspection of the margin data in Table 1 and Figure 4 reveal that the largest margins usually occur when crude oil cost and the wholesale gasoline price are falling from month-to-month. However, when they are stable or rising, the margin tends to be relatively stable (Table 2 and Figure 4). (See the note in the box below for additional information on changes in the retail margin).

To model the complex interactions just noted, we create a variable (D) which consists of the month-to-month changes in wholesale prices ( $\Delta W$ ) when  $\Delta W$  is  $< 0$ , and a value of 0 when  $\Delta W \geq 0$  (Table 2).

The estimated equation is:

(2)  $R = 79.22 + 1.01*W - 0.685*D$ . The equation explains 99 percent of the month-to-month change in the average retail price (Figure 3). The coefficient on the D variable indicates that the retail margin increases by 0.685 cent for each 1-cent decrease in the wholesale price, or about 6.9 cents for a 10-cent decrease. The coefficient on W indicates a nearly cent-for-cent change in retail and wholesale prices, assuming the retail margin does not change.

The equations are applied as follows:

(2)  $R = 79.22 + 1.01*W - 0.685*D$  when  $\Delta W$  is  $< 0$  (D = actual value of  $\Delta W$ ), and

(2.1)  $R = 79.22 + 1.01*W$ , when  $\Delta W$  is  $\geq 0$  (D = 0).

An interesting example of how a change in the retail margin affects the retail price is provided by the price and margin data for December 2021 and January 2022. The refiner acquisition cost of crude oil rose by \$8.21 per barrel from December to January, and the wholesale price of gasoline increased 12 cents per gallon. However, the monthly average retail price did not change as a 12-cent decline in the margin exactly offset the effect of an increase in the wholesale price (Tables 1 and 2).

Our model performs well as it predicts a very slight change – less than one-half cent – in the retail price from December 2021 to January 2022. The change in the monthly average retail price may be expressed as:

(3)  $\Delta R = 1.01*\Delta W - 0.685*\Delta D$ .

In this situation,  $\Delta D = 0 - (-18) = 18$ , and  $\Delta W = 12$  cents. Therefore,  $\Delta R = (1.01*12) - (0.685*18) = 12.1 - 12.3 = -0.2$  cent.

The inclusion of the D variable improved the explanatory power of the statistical model, and it was highly significant statistically. Nevertheless, we wanted to verify that it was a valid proxy for changes in the retail margin. To that end we estimated the following equation for the retail margin (M) for the 10 months in which the average wholesale price fell from the previous month ( $\Delta W < 0$ ):

$M = 82.3 - 0.634*\Delta W$ , where the values for  $\Delta W$  are  $< 0$  (Figure 4). The equation explained 83 percent of month-to-month changes in retail margins. The slope coefficient is remarkably close to the coefficient on the D variable (-0.685) in Equation 2.

## May 2022 Wholesale and Retail Prices

Our model did not perform well in predicting average wholesale and retail gasoline prices for May 2022. For the 28 months prior to May, the average residual – difference between actual and predicted price – was 7 cents per gallon for wholesale price predictions and 4 cents for retail price predictions. The residuals for May were 41 cents for the wholesale price and 24 cents for the retail price (Figures 1 and 3).

The increase in the refiner acquisition cost from April to May, \$7.77 per barrel, indicates an increase in the monthly average wholesale price of 24 cents per gallon (Equation 1). The wholesale price, however, rose by 59 cents to 385 cents per gallon. This unexpected increase resulted from an unusual spike in the refiner or wholesale margin – wholesale price less the acquisition cost of crude oil. The refiner margin was a record high 128 cents per gallon in May, 41 cents above the April margin and 2 and ½ times the average margin for the 29-month study. Various sources attribute the higher refiner margins in recent months to low global inventories of crude oil relative to demand, a decline in Russian oil exports, and a reduction in U. S. refining capacity over the past two years (Figure 5).

Meanwhile, the retail price was less than expected based on the 385 cents per gallon wholesale price. Equation 2 indicates a 59.6 cents per gallon increase in the retail price based on the 59 cents increase in the wholesale price. 26x cents of this expected gain were wiped out by an inexplicable decline in the retail margin, from 85 cents in April to 59 cents in May. The retail margin, normally about 35 cents higher than the wholesale margin, was 69 cents less than the wholesale margin in May.

### Conclusion

The statistical model developed in this study only applies when predicting U.S. average monthly gasoline prices. Predicting the wholesale price of gasoline is fairly straightforward. Changes in the wholesale price are heavily dependent upon changes in the cost of crude oil to refineries. Predicting retail prices is more complicated. Retail station owners pay the wholesale price for the gasoline they purchase. Obviously, changes in the wholesale price weigh heavily on retail pricing decisions. By definition, the retail price is the wholesale price plus the retail margin. There is a tendency for the retail margin to increase during times of falling wholesale gasoline prices. Therefore, for any given change in the wholesale price, the change in the monthly average retail price depends on whether the wholesale price is rising or falling - the change is smaller when the wholesale price is falling than when it is rising.

## Tables and Charts

Year / Month	Refiner Crude Oil Acquisition Cost <sup>1</sup>	Gasoline Wholesale Price <sup>1</sup>	Gasoline Retail Price <sup>1</sup>	Retail Price minus Wholesale Price
	Dol. per barrel <sup>2</sup>	Cents per gallon	Cents per gallon <sup>3</sup>	Cents per gallon
2020:				
January	57.92	174	255	81
February	51.37	167	244	77
March	32.55	113	223	110
April	19.32	65	184	119
May	23.55	105	187	82
June	36.8	131	208	77
July	40.08	138	218	80
August	42.42	139	218	79
September	39.81	135	218	83
October	39.21	131	216	85
November	40.68	129	211	82
December	46.2	139	220	81
2021:				
January	51.36	158	233	75
February	58.39	178	250	72
March	61.96	201	281	80
April	62.39	206	286	80
May	65.15	218	299	81
June	70.54	225	306	81
July	71.97	234	314	80
August	67.87	230	316	86
September	71.09	231	318	87
October	78.88	249	329	80
November	78.41	248	339	91
December	71.98	230	331	101
2022:				
January	80.19	242	331	89
February	90.28	264	352	88
March	104.07	323	422	99
April	100.28	326	411	85
May	108.05	385	444	59

<sup>1</sup> U.S. Energy Information Administration (EIA), *Short-Term Energy Outlook Data Browser*; accessed June 7, 2022: <https://www.eia.gov/outlooks/steo/data/browser/>. <sup>2</sup> There are 42 gallons of oil in a barrel. According to EIA, 19 to 20 gallons of gasoline are normally produced from a barrel of crude oil. <sup>3</sup> Includes Federal and State taxes.

Table 2. Data for the D Variable, Equation 2.

Month/ Year	W	$\Delta W$	D
2020:	Cents per gallon	Cents per gallon	Cents per gallon
January	174	-2	-2
February	167	-7	-7
March	113	-54	-54
April	65	-48	-48
May	105	40	0
June	131	26	0
July	138	7	0
August	139	1	0
September	135	-4	-4
October	131	-4	-4
November	129	-2	-2
December	139	10	0
2021:			
January	158	19	0
February	178	20	0
March	201	23	0
April	206	5	0
May	218	12	0
June	225	7	0
July	234	9	0
August	230	-4	-4
September	231	1	0
October	249	18	0
November	248	-1	-1
December	230	-18	-18
2022:			
January	242	12	0
February	264	22	0
March	323	59	0
April	326	3	0
May	385	59	0

Figure 1. Trends in Monthly Average Fuel Prices

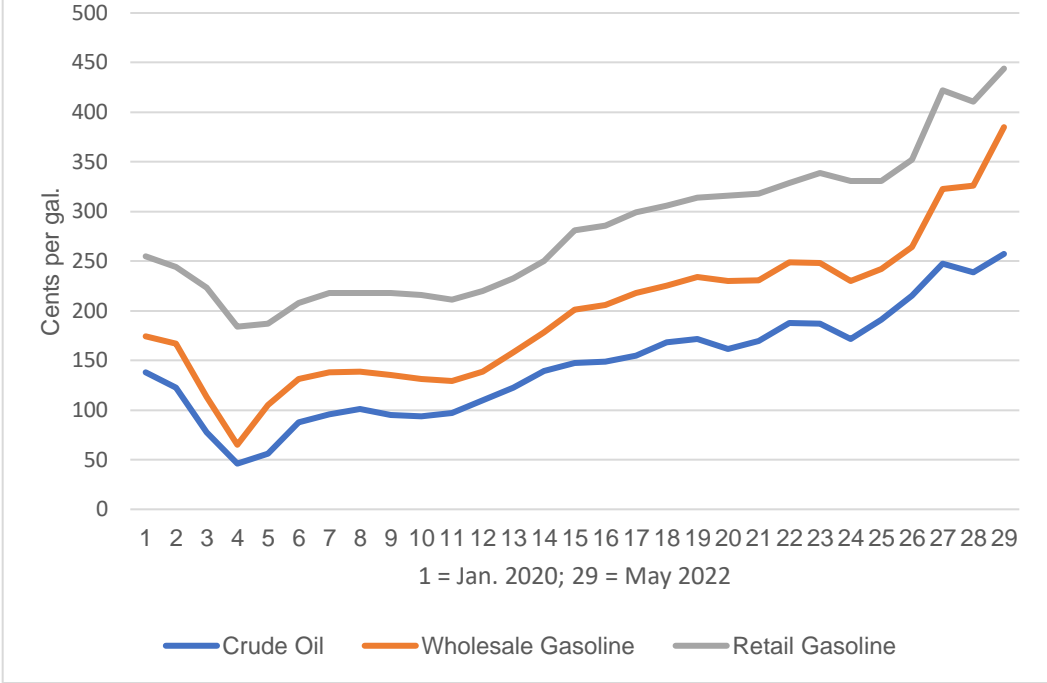


Figure 2. Wholesale Gasoline Price vs. Refiner Acquisition Cost of Crude Oil

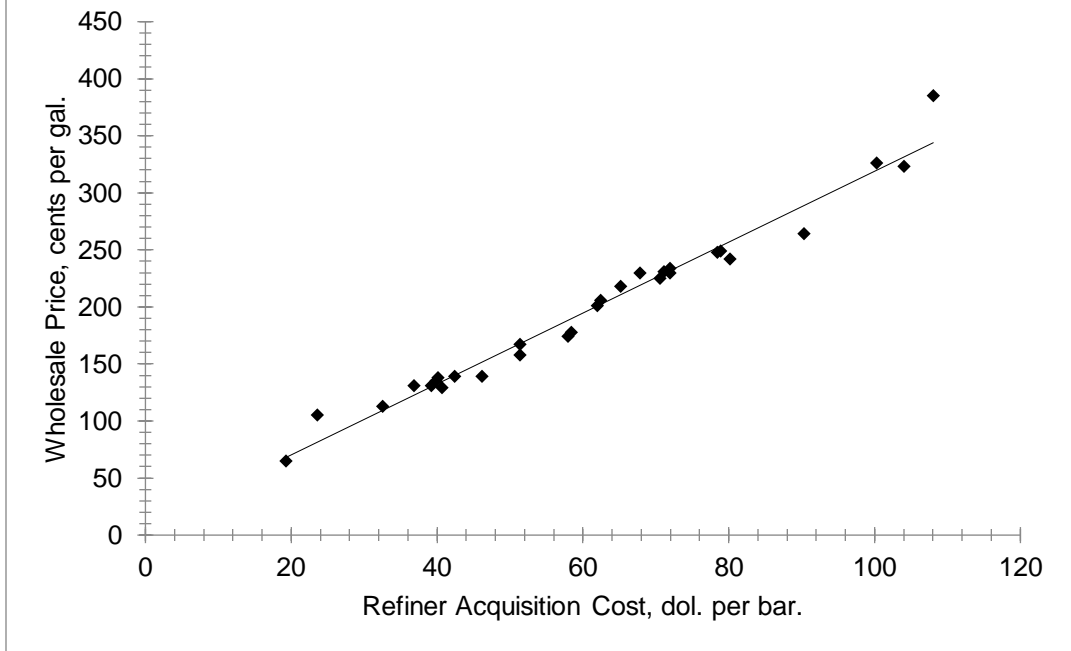


Figure 3. Actual vs. Predicted Retail Prices, Equation 2

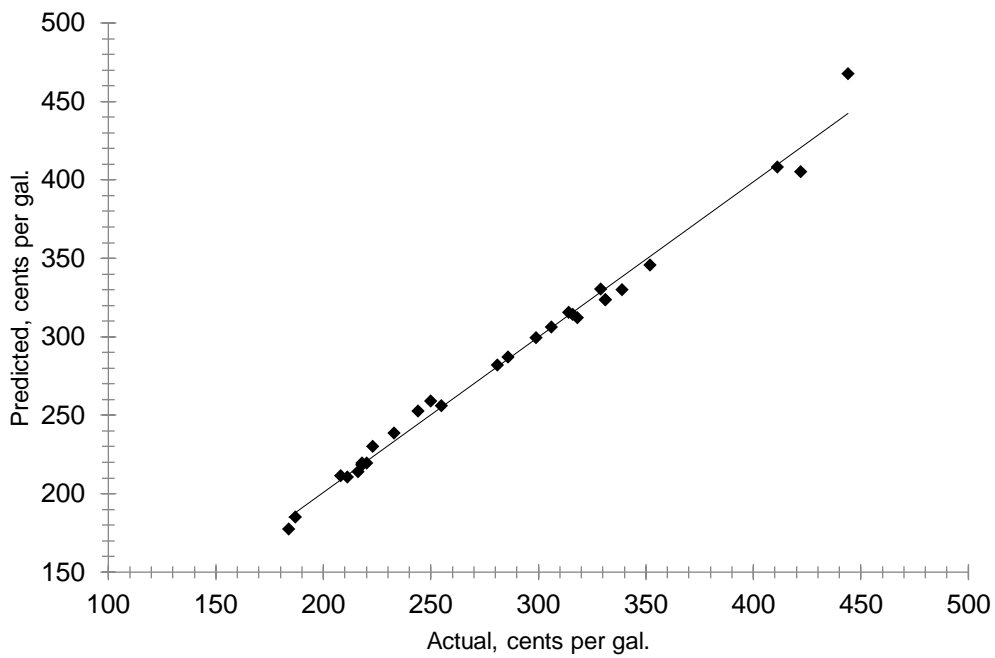


Figure 4. Retail Margin versus Change in Wholesale Gasoline Price

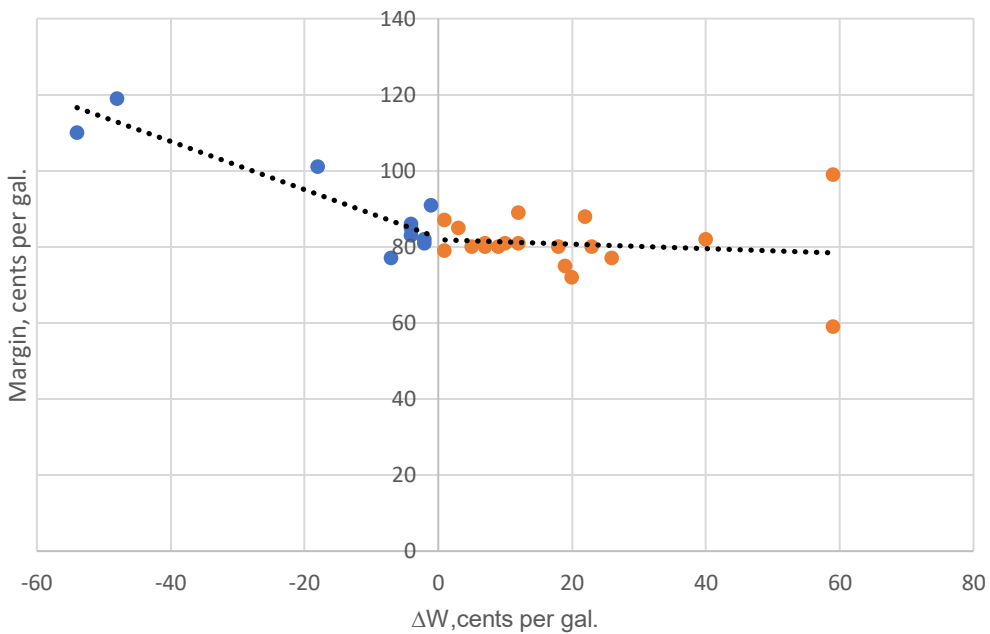




Figure 5. Retail and Wholesale Margins

